Progress in Ultrasonic Nondestructive Testing of Pressure Vessels

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Introduction

Progress in the development of a synthetic aperture focusing system for ultrasonic pulse-echo flaw evaluations is described. Progress has been made in several areas. Each of them is described very briefly in the following sections.

(a) Spotlight Mode Scanning

Last year's report described a different method of synthetic aperture ultrasonic focusing which nevertheless uses a single transducer operating in pulse-echo mode. Called spotlight-mode, this technique uses a narrow beam-width transducer which is controlled so that, as it is scanned across the test specimen a small region is continuously illuminated. Since then, tests have been made which confirm the earlier prediction of higher signal-to-noise ratios at deeper depths using this technique. Also, tests have been made to examine the resolving power of the system.

(b) Graphical Display of Flaws

This section describes ongoing work in the area of graphical display of flaws. In the annual report for FY-78 two techniques for displaying flaws were described:

(1) Study of PC PLOT and modifications and improvements based on this study.
(2) Study of GRY PLOT and modifications and improvements based on this study.
(3) Design and implementation of pseudo color techniques for visual display.
(4) Investigation of shading techniques for displaying flaws.
(5) Feasibility study for doing real time display of rotating views of flaws.

(c) Investigation of Real Time Processing

As pointed out in the FY-79 report, there is a theoretical limit to the time required to process a data set if one uses a Von Neumann type architecture. Since the FY-78 report, work has been done to see how closely we could approach this ideal with our own computer by means of more efficient programming.

One of the constraints to faster processing was the way the records are stored on disc (sequentially). By using a buffering technique and hand coding the critical inner loop in the processing, we have cut down the processing by a factor of 10 or so on most data sets. Investigation is under way to determine the type of architecture that is needed to do real time processing.

(d) Deconvolution of A-scan Data

As reported in FY-78 and this year's progress report a deconvolution method based on linear prediction analysis can sharpen the time response of existing underdamped ultrasonic transducers. However, a limitation of this deconvolution method is that it requires an impulse response of a transducer to have a specific phase characteristics, namely, either the minimum phase or the maximum phase. Otherwise the outcome becomes noisy. In order to overcome this problem, an advanced signal processing scheme known as complex cepstrum computation was employed to separate the original impulse response into minimum and maximum phase components so that the linear prediction analysis can be applied to them separately. A deconvolution filter based on this principle has been constructed and we are getting very encouraging experimental results.

(e) Calibration and Parameter Study

The motivation for this study is to more clearly define the effect of the synthetic aperture processing program on the final processed image and to be able to more conveniently characterize the resolution of the processing. Once the procedures for characterizing the effects of the synthetic aperture on processed images have been developed it is possible to measure the effects of changes in the various parameters used in data collection and processing. Questions that are of interest to us are (1) How much random error can be tolerated in the scanning device which locates the transducer at a given location? (2) How rough can the front surface of the sample be? (3) What are the effects of pulse shape and pulse width? etc.

References

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1603 216